

Morphology of the alimentary and reproductive organs in some Gryllidae (Orthoptera)

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Introduction

Prior to this study, little work existed on the morphology of the internal organs particularly the reproductive structures of Gryllidae. The accessory glands of the male reproductive organs in Gryllidae were known as far back as 1836 (Burmeister, 1836) and subsequent authors, such as Dufour (1841), Siebold (1845), Henneguy (1904) and Ito (1924) have studied them. All these efforts are well summarized by Spann (1934). But these authors have dwelt on the possible functions of the accessory glands, and no work seems to have been done on the fine structure of these organs. Further, to the knowledge of the authors, the histology of the bulbus ejaculatorius has seldom been studied. However, the structure of the proventriculus in the alimentary canal of Gryllidae has been studied in considerable detail by some workers (Du Porte, 1918 and Judd, 1948). The purpose of this investigation was to study the morphology of the alimentary and reproductive organs of some Gryllidae with a view to fill gaps in our knowledge of these structures.

Materials and methods

Three species of crickets, *Gryllus bimaculatus* De Geer, *Teleogryllus posticus* (Walker) and *Teleogryllus* sp. were collected at Legon near Accra on the University campus. Insects were anaesthetized and dissected in tap water. The tissues were fixed in Bouin's fluid for 12 hours and stained in either Masson's trichome stain or in Delafields haematoxylin, or in Mallory's triple stain. Sections were cut at 5—7 μ . The Mallory's stain was used with the modification that sections were mordanted for 7—10 minutes in Mercuric chloride-acetic acid, stained for 10 seconds in Acid Fuchsin, and the times in phosphomolybic acid and Mallory's stain were 55—60 seconds and 60 seconds respectively. The histology of the proventriculus of three gryllid species was studied, but in the case of mushroom-shaped glands, only the histology of *G. bimaculatus* De Geer was examined.

Gross morphology

Alimentary canal (Fig. 1)

The gut consists of oesophagus, crop, proventriculus, caecae, midgut and hindgut with the malpighian tubules arising from the junction of the midgut and hindgut (Fig. 1). Except in the form of the malpighian tubules, the morphology of the alimentary canal is similar in all the three species studied. *T. posticus* and *Teleogryllus* sp. have an identical arrangement of malpighian tubules, in each case five main tubules arise from the junction of the mid- and hindgut. One of the tubules is greatly enlarged and bears at the terminal end numerous smaller tubules (Fig. 1). All the tubules are yellowish in colour and asymmetrical in arrangement. In *G. bimaculatus*, there is only one tubule arising at the junction of the mid- and hindgut. This tubule is relatively large, stalked and bears at its terminal end, as in *T. posticus* and *Teleogryllus* sp., numerous small tubules, somewhat yellowish and asymmetrically arranged. The caecae and rectal papillae are well developed in all three species.

Female reproductive organs (Fig. 2)

The adult female reproductive organs consist of a pair of ovarioles each bearing 65 ovarioles in *G. bimaculatus* and 70 ovarioles each in *Teleogryllus* sp. and *T. posticus*. A pair of lateral oviducts, a spermatheca with its long spermathecal duct, bursa copulatrix, and the vagina can also be made out in the female. A brown chitinous organ is located on the dorsal wall of the vagina. In dorsal view this organ appears as an isoscles triangle. However, when freed from other tissues to which it is attached, it appears to have the shape of a kite. The size of the organs varies with the size of species in question and probably also with the age of the specimen.

Male reproductive organs (Fig. 3)

The adult male reproductive organs consist of a pair of whitish, almost uniformly broad testes, long paired vasa deferentia, posteriorly placed paired seminal vesicles and an ejaculatory duct which swells anteriorly. Each testis consists of about 140 follicles which are nearly spindle-shaped. The mushroom-shaped gland is a mop-like structure situated medioposteriorly and extending from the terminal end to about the middle of the 5th sternite. The ejaculatory duct swells at the anterior end to form the bulbus ejaculatorius. It is into this bulb that the accessory glands, consisting of a vast number of tubules, open. Four types of such tubules can be distinguished (6 specimens were examined and measured):

1. Long milky white tubules: these tubules curve posteriorly whereas the others point anteriorly to varying extent. Length 3.60—3.65 mm (mean 3.61 mm); width 0.19—0.23 mm (mean 0.20 mm).
2. White intermediate tubules, length: 1.00—1.25 mm (mean 1.15 mm); width: 0.09—0.15 mm (mean 0.12 mm). Both the long white tubules and the intermediate white tubules are milky in appearance.

3. Brown intermediate tubules which are dirty white in colour and are the least in number. Length 1.00—1.25 mm (mean 1.14 mm); width, 0.09—0.15 mm (mean 0.12 mm).
4. Short tubules which are whitish, with a mean length ranging from 0.35—0.50 mm (mean 0.42 mm) and width from 0.14—0.18 mm (mean 0.16 mm).

The seminal vesicles are completely hidden among the above mentioned tubules.

Histology

Proventriculus

The histology of the proventriculus in all the three species studied was found to be identical to that reported in *Gryllus pennsylvanicus* Burm. by Du Porte (1918). The proventriculus has a complicated system of teeth which include sharp denticles and lateral teeth. It also has powerful longitudinal and circular muscles, especially in the posterior region. The histology of the other sections of the alimentary organs was not attempted.

The mushroom-shaped gland

Accessory glands:

The histology of the four kinds of tubules is somewhat similar. A major difference is however seen between the structure of the long tubules and the intermediate tubules and also in the secretions of the different tubules. In the long tubules, the nuclei of the epithelium are oval and large whereas in the white intermediate tubules, the nuclei are elongated. The brown intermediate tubules have nuclei similar to those of the white intermediate tubules. The nuclei of the short tubules are also elongated but smaller in size. The long tubules apparently produce two types of secretions. In stained preparations, the secretion of the long tubule consists of an outer layer which stains deep red and an inner layer which stains light blue with Mallory's stain and is finely granular (Fig. 4). The white intermediate tubules have only one layer of secretion which stains deep blue with Mallory's stain and is coarsely granular (Fig. 5).

The brown intermediate tubules have a secretion similar to that of white intermediate tubules. The brown intermediate tubules are histologically similar to the white intermediate tubules in all respects, the only difference seems to lie in their colour *in situ*. The short tubules are histologically similar to the white intermediate excepting the secretions they produce. The secretion of the short tubules stains light blue whereas that of the white tubules stains deep blue. The short tubules are of course shorter but wider in diameter than the intermediate tubules.

Bulbus ejaculatorius:

The structure of this organ is complex. It is lined by a single layered epithelium comprising three types of cells arranged in three distinct zones (Figs. 6—7). The first or anterior epithelial zone (Fig. 6) consists of tall columnar secretory cells and is thrown into many folds. All the brown tubules,

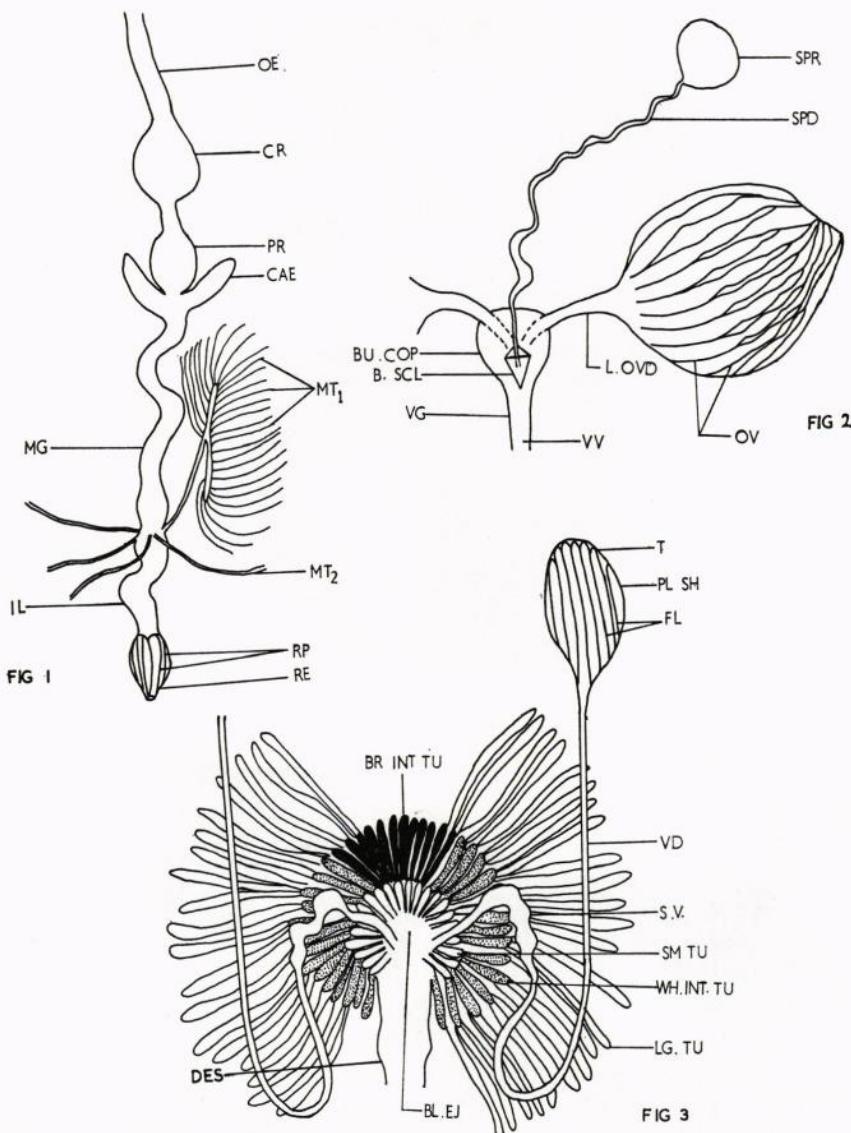


Fig. 1. The alimentary organs of *T. posticus*.

Fig. 2. Dorsal view of the female reproductive system (ovary on the left side omitted) of *Teleogryllus sp.*

Fig. 3. Dorsal view of the male reproductive organs of *G. bimaculatus*.

most of the short tubules, and a few white intermediate tubules open into this zone. The epithelium of this zone is continuous with that of the second or the middle zone which has very tall columnar and densely staining secretory cells, quite similar to those of the first zone. The second zone is continuous with the third zone the cells of which in turn are continuous

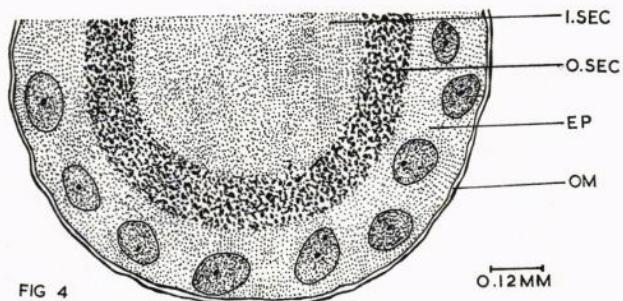


FIG. 4

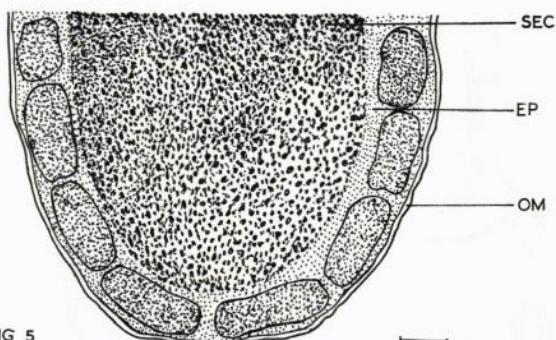


FIG. 5

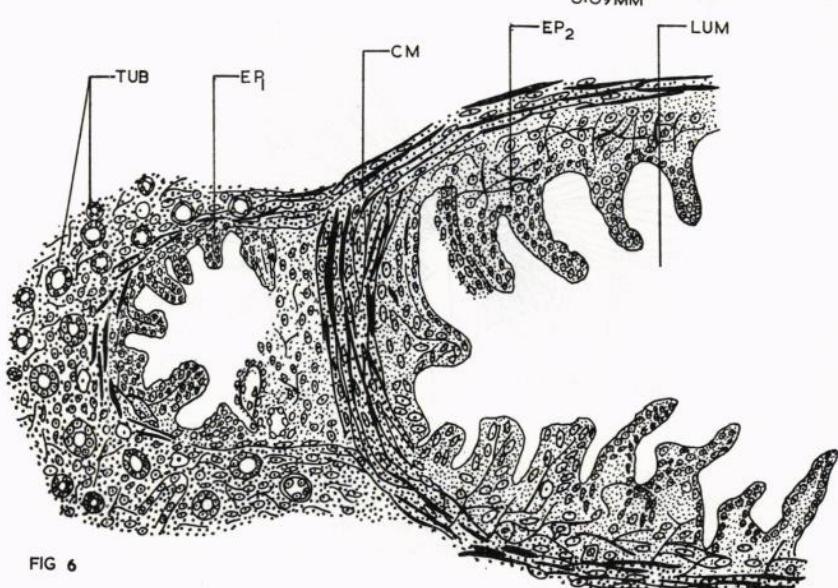


FIG. 6

Fig. 4. Tranverse section of the longitudinal tubule of the mushroom-shaped gland in *G. bimaculatus*.

Fig. 5. T. S. of the intermediate tubule of the mushroom-shaped gland in *G. bimaculatus*.
Fig. 6. L. S. of the bulbus ejaculatorius showing the epithelia of first and second zones.

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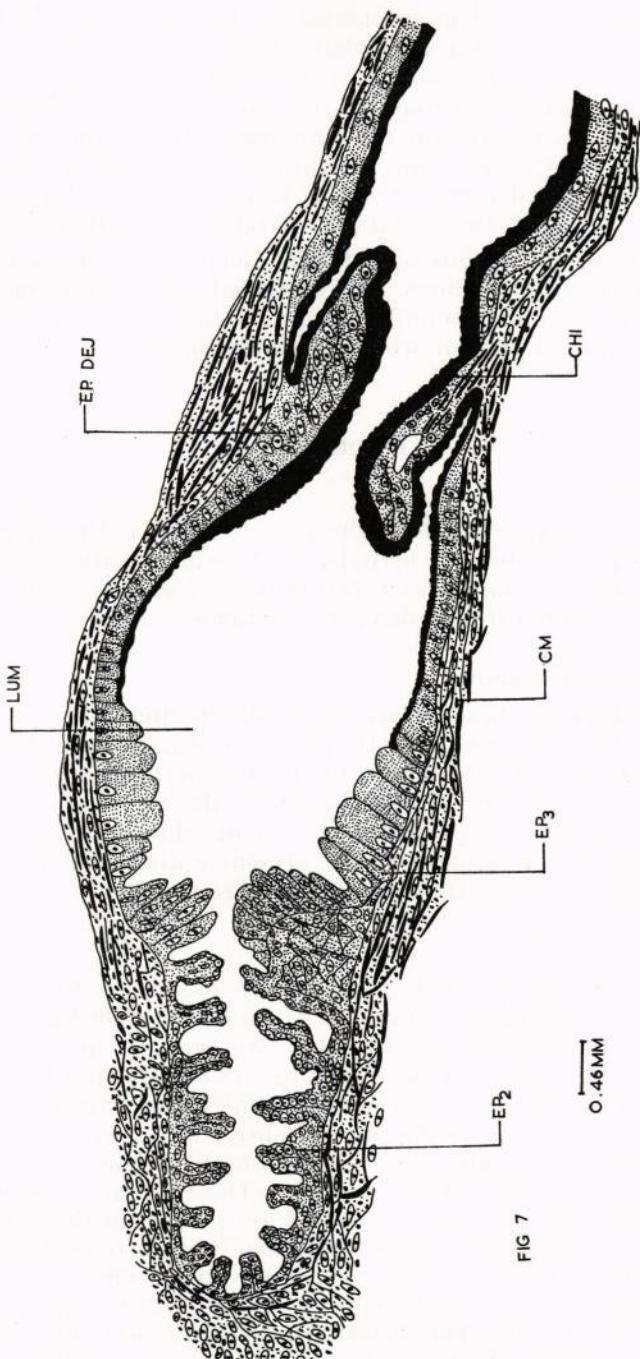


Fig. 7. L. S. of the bulbus ejaculatories showing the epithelia of second and third zones.

with epithelium of the ductus ejaculatorius. The epithelium in the third or posterior zone has large and somewhat cuboidal cells. Some of the cells of this layer have distinct boundaries while those near to the region of the epithelium of the ductus ejaculatorius do not have distinct boundaries. The long tubules and most of the intermediate tubules open into the second zone and no tubules seem to open into the third zone. The three epithelial zones have a common central lumen which is continuous with the epithelium of ductus ejaculatorius. Secretory products are released into this lumen.

The epithelia of the bulbus and ductus ejaculatorius are all surrounded by thick layers of muscle fibres. The epithelial cells of the ductus ejaculatorius do not have distinct boundaries and contain ovoid nuclei. These cells secrete a thick chitinous intima which has rough surface.

Discussion

Alimentary canal:

One important feature noted in the present work is the variation in the number of malpighian tubules between the two genera that were examined. This doesn't seem to have been reported earlier. The structure of the proventriculus is similar to that described by earlier authors.

Female reproductive organs:

The morphology of these organs is similar to that of *Gryllus assimilis* Fabr. (Spann, 1934). The species of the present work, however, have relatively fewer ovarioles (65—70) compared to the 125 of *Gryllus assimilis*. Spann (1934) refers to the brown chitinous organ on the dorsal wall of the vagina as the bursa copulatrix. Snodgrass (1937) calls this structure as the spermathecal spout. In the opinion of the present author the sclerite helps to prevent the displacement of the duct during extreme activity.

Male reproductive organs:

The morphology of the male reproductive organs in Gryllidae, as said earlier, has been studied by a number of authors. According to Ito (1924) and Spann (1934) Gryllidae possess only two types of accessory glands in their reproductive organs, while Packard (1898) stated that the seminal vesicles bore numerous long and short tubules (his utriculi majores and breviores). The tubules, according to our observations, are not borne on the seminal vesicles. Rather, they are present on the bulbus ejaculatorius and almost entirely cover the seminal vesicles. The present work also demonstrates that four different types of tubules are present in Gryllidae. The fact that the secretions from the different tubules stain differently suggests that they are chemically different. These secretions may contribute to the formation of the layers of the spermatophore (Spann, 1934), and possibly have other functions as well. The brown intermediate tubules deserve some comment here. They were found to be histologically similar to the white intermediate tubules in all respects, the only difference is in their colour *in situ*. It is probable that the coloration is due to the storage of some metabolic

waste products. The structural complexity of the bulbus may have some functional significance of which we are at present ignorant. There are however, interesting similarities in the structure of the mushroom-shaped gland in Gryllidae and Dictyoptera (Louis and Kumar, 1971).

Summary

The morphology of the alimentary and reproductive organs in three species of Gryllidae was studied. The general organization of the alimentary organs in the species was similar but the malpighian tubules of *Teleogryllus posticus* and *Teleogryllus* sp. were identical and different from those of *Gryllus bimaculatus*. The female reproductive organs consist of 65 ovarioles in *G. bimaculata* and 70 ovarioles in *T. posticus* and *Teleogryllus* sp. Each species bears a single median spermatheca with a long spermathecal duct. The mushroom-shaped gland was found to consist of four different types of tubules each of which produces a distinct secretion.

It was found for the first time that the bulbus ejaculatorius is a complex structure the epithelium of which is organized into three different zones and externally the bulbus is invested by layers of muscle fibres. The number of follicles in each testis is about 140.

Acknowledgements

We wish to thank Dr. David Ragge and Mr. John Huxley of the Department of Entomology, British Museum (Natural History) for their assistance in naming the species used in this work.

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Abbreviations used in text-figures

B. SCL, brown sclerite	MG, midgut
BL. EJ, bulbus ejaculatorius	MT ₁ , small malpighian tubules
BR INT TU, brown intermediate tubule	MT ₂ , large malpighian tubule
BU. COP, bursa copulatrix	OE, oesophagus
CAE, caeca	OM, outer membrane
CHI, chitinous intima	O. SEC, outer secretion
CM, circular muscle	OV, ovarioles
CR, crop	PL. SH, peritoneal sheath
DES, ductus ejaculatorius	PR, proventriculus
EP, epithelium	RE, rectum
EP ₁ , epithelium of the first zone	RP, rectal papillae
EP ₂ , epithelium of the second zone	SEC, secretion
EP ₃ , epithelium of the third zone	SCL, sclerite
EP. DEJ, epithelium of the ductus ejaculatorius	SM TU, short tubule
FL, follicle	SPR, spermatheca
IL, ileum	SV, seminal vesicle
I. SEC, inner layer of secretion	T, testis
LG. TU, longitudinal tubules	TUB, tubule
LM, longitudinal muscle	VG, vagina
L. OVD, lateral oviduct	VD, vas deferens
LUM, lumen	VV, vulva
	WH. INT. TU, white intermediate tubule